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## Precipitates Suppress Mobility Of Metals in Soil and Water

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**C**ontamination of soil and water with hazardous metals – such as cadmium, copper, lead, and nickel – is a national environmental concern. Excessive amounts of metals accumulating in soils can be toxic to humans, animals, and plants.

Natural soil concentrations of nickel are normally less than 50 parts per million (ppm), but they have increased over time. This increase may be due to activities at industries like tanneries and smelters. Also, the disposal of sewage sludge may increase nickel concentrations in soils to more than 2,500 ppm – levels that are potentially toxic to humans, animals, and plants.

Predicting the movement of environmental contaminants requires an understanding of how metals are retained on the surface of soil particles. Metal reten-

tion (or sorption) on the surface of soil particles decreases the ability of a contaminant to move through soil and water.

USDA's National Research Initiative (NRI) Competitive Grants Program sponsors research at the University of Delaware on the rates and mechanisms of nickel sorption and release in soils.

### INVESTIGATING METAL PRECIPITATES

Sorption reactions can occur over time scales ranging from milliseconds to months. The researchers use spectroscopic and microscopic techniques to describe these reactions. For example, they can study soils *in situ* (i.e., in their natural state) without drying or placing the soil under high vacuum.

Two excellent *in-situ* techniques are x-ray absorption spectroscopy (XAS) and scanning force microscopy (SFM).

LEFT: SOIL SURFACE WITHOUT  
NICKEL SURFACE PRECIPITATES.

RIGHT: FORMATION OF NICKEL  
SURFACE PRECIPITATES AFTER  
3 HOURS.

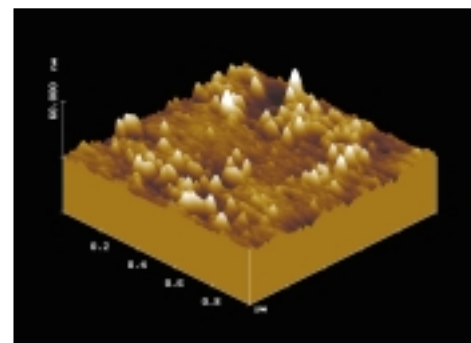
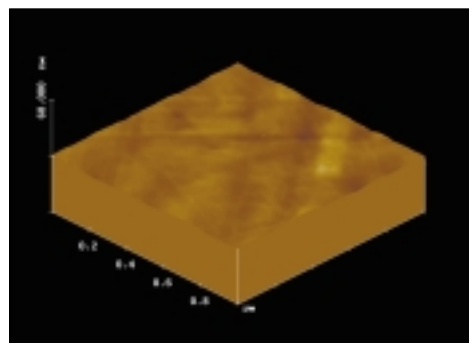


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*The formation of surface precipitates greatly diminishes the mobility of metals in the environment.*

XAS is used to determine the local chemical environment of a metal on a soil particle surface – such as the bond distances between metals and the identification of metals – even when the metal is at low concentrations.

SFM provides high-resolution images of changes in soil surface microtopography at the nanometer (one billionth of a meter) scale and in real time.

XAS analyses of nickel sorption on pyrophyllite, a clay mineral, showed the three-dimensional nickel and aluminum hydroxide phase growing on the mineral surface (i.e., a surface precipitate) with increasing sorption time and taking about 15 minutes to form. Similarly, these phases take about 30 minutes to form in field soils.

The researchers also observed the formation of mixed metal phases with zinc, another agriculturally and environmentally important metal. The formation of mixed metal surface precipitates is important because it occurs at pH levels commonly found in soils, at low metal concentrations, and at relatively rapid time scales.

Before these molecular scale techniques were available, it was thought that surface precipitates only formed at high metal concentrations in the soil solution and on the soil surface and only after long reaction times.

To observe the growth of the mixed metal surface precipitates on mineral surfaces, the researchers used SFM, where one can see the size, shape, and distribution of metal complexes on soil surfaces. The photos on the front show a pyrophyllite surface without the presence of nickel (left) and the pyrophyllite surface after reaction with nickel for more than 3 hours (right). The appearance of peaks and valleys, representing the growth of nickel surface precipitates, is enhanced with time.

### IMPACT

The formation of mixed metal surface precipitates could be an important way to sequester and stabilize soil and water contaminants so that they are less mobile and less likely to be taken up by organisms. These data show that the formation of surface precipitates greatly diminishes the mobility of metals in the environment.

These findings should be included in models of sorption and desorption processes to accurately predict metal movement in soil and water environments. The results of this research provide the knowledge needed for establishing methods to control the movement of toxins and contaminants in soil and water that would otherwise incapacitate crop, range, and forest lands. ❖

The research reported in this factsheet came out of the Soils and Soil Biology Program, Natural Resources and Environment Division, National Research Initiative Competitive Grants Program. To be placed on the mailing list for this publication or to receive additional information, please contact the NRI (202/401-5022 or [NRICGP@reeusda.gov](mailto:NRICGP@reeusda.gov)). The factsheet also is accessible via the NRI section of the Cooperative State Research, Education, and Extension Service website (<http://www.reeusda.gov/nri>).

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